

FDNY

World Trade Center Health Studies

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September 11, 2001

The terrorist attack on the World Trade Center and its consequent collapses killed 2,800 persons, including 343 FDNY rescue/recovery workers.

Overall, ~ 16,000 FDNY rescue workers participated in the intense rescue/recovery effort, which started immediately and continued for more than 10 months.

1,600 FDNY firefighters and EMS workers were present when the buildings came down and 6,600 were there by the end of day 1.



WTC DUST

- Small & Large particles
- Alkaline pH (ex. Lye)
- Larger the size, the more alkaline the pH
- Large Particles reached lower airways
 - High concentrations
 - Mouth breathing

Particle Size (MMAD μm)

2.5

10

53

pH

~8.1

>10.0

Sources: Chen et al; Lancet 2002;360:S37-8.

Gavett et al; Environ Health Perspect 2003;111:981-91

Review of WTC Exposures



The exposure mix (partial list):

- Pulverized cement, gypsum
- Pulverized glass
- Asbestos
- Silica
- Fibrous glass
- Heavy metals
- Volatile organic compounds
- Organic products of the combustion of bldg components & jet fuel
 - PAHs, dioxins, PCBs, etc

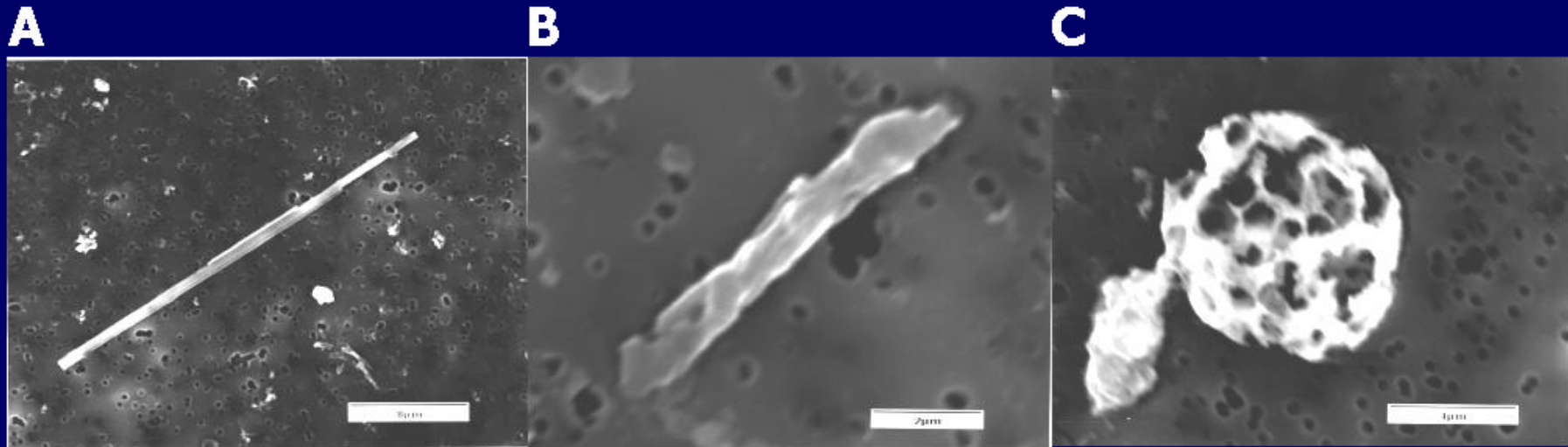
Dust, surgical, or N95 TB masks are **NOT** the type of respiratory protection that first responders should wear at a **FIRE** or **HAZMAT** event

P-100 half face is the right respirator but **NOT** available early on & difficult to wear



FDNY Firefighter with Pneumonitis

Bronchoscopic Lavage – 3 weeks later



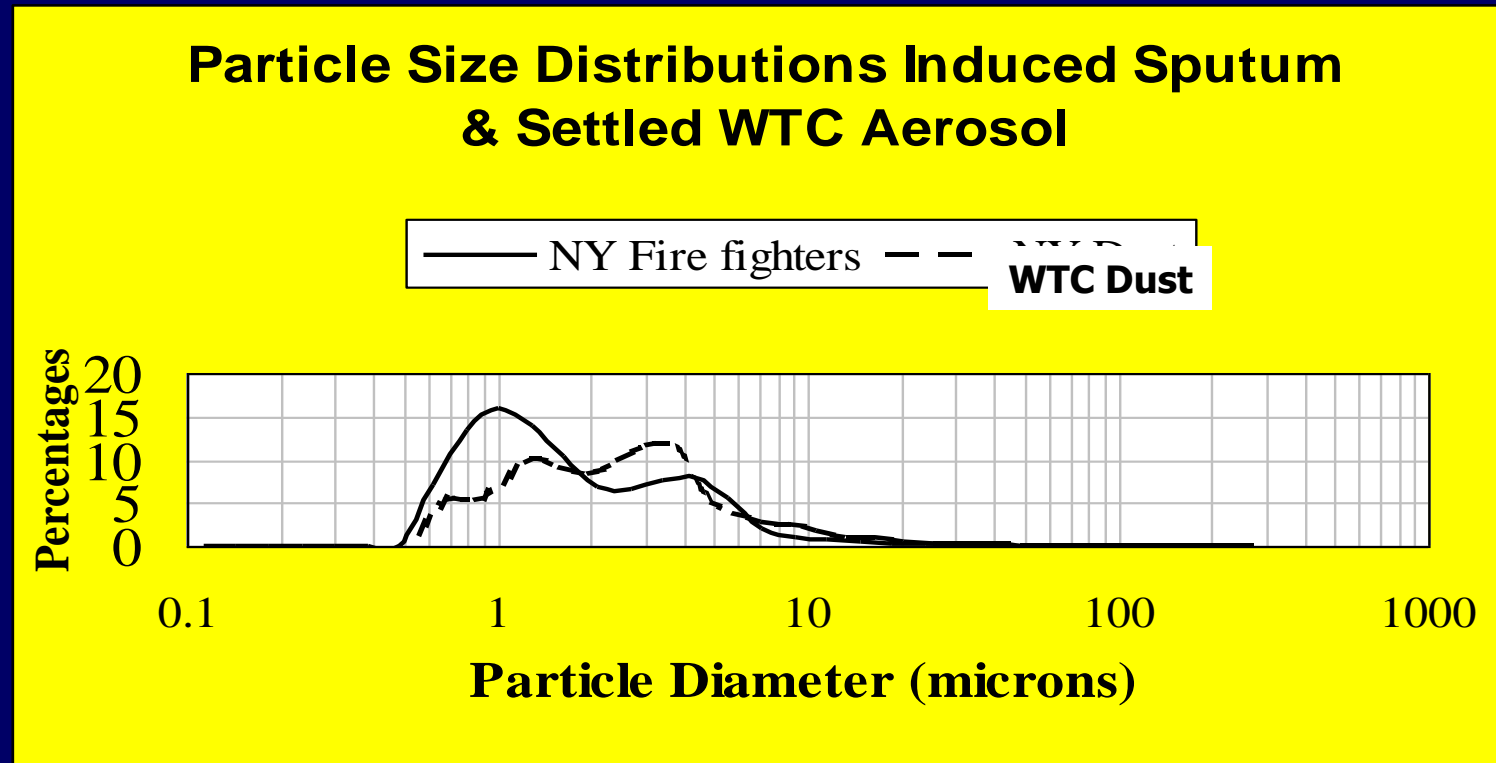
Uncoated asbestos fiber

Degraded fibrous glass

Fly ash particle

Rom, Weiden, Prezant, et al. Am J Resp Crit Care Med 2002, 166; 797

FDNY Firefighter Dust-Induced Inflammation Induced Sputum – 10 months later



Fireman, Kelly, Prezant, et al. Environmental Health Perspectives; 2004

FDNY WTC Monitoring & Treatment Program

9/11 WTC
Exposures

LONG-TERM MEDICAL MONITORING
& TREATMENT PROGRAM

Mental Health

Respiratory

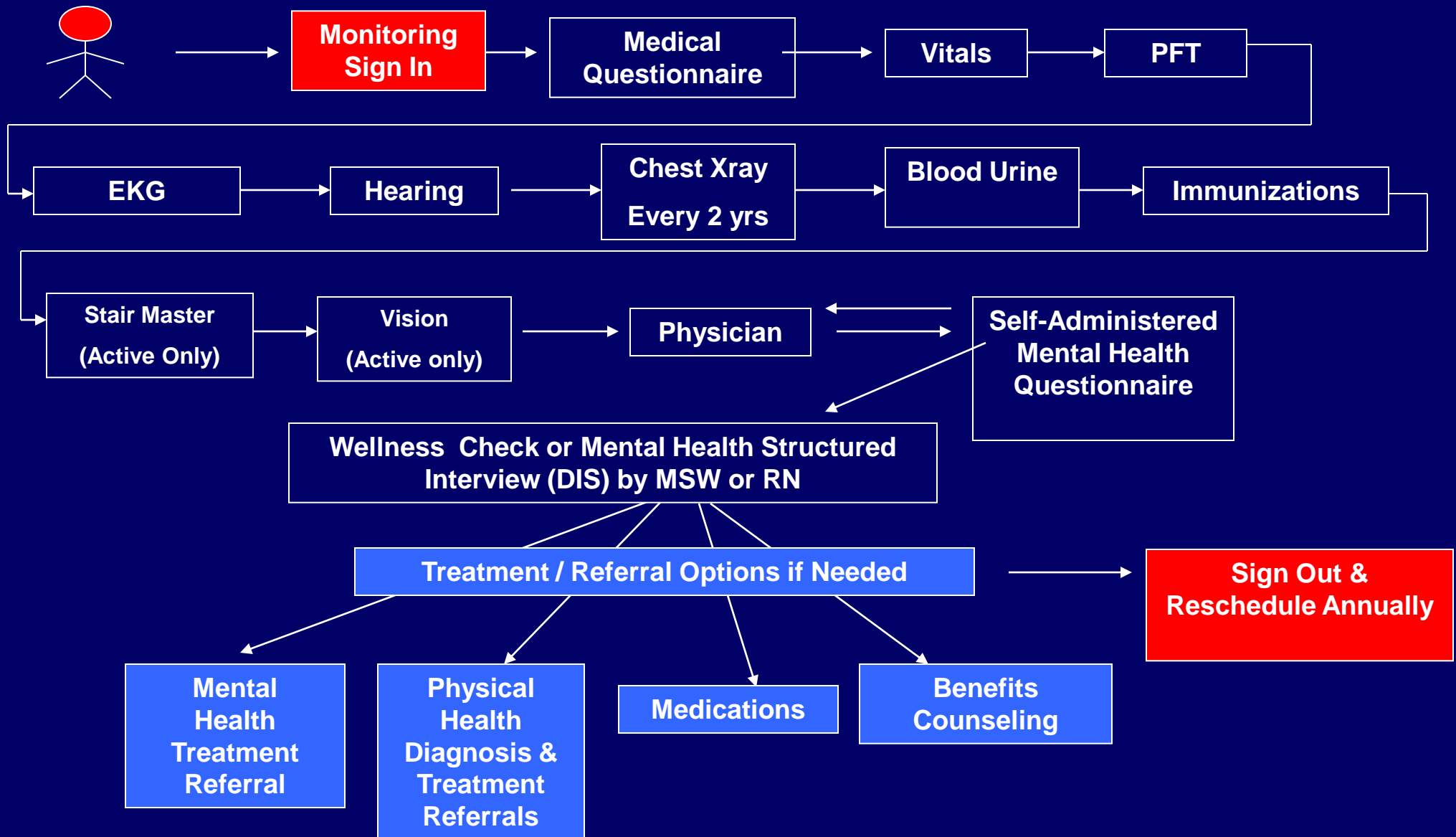
Late Emerging
Diseases

FDNY-WTC ARRIVAL GRPS

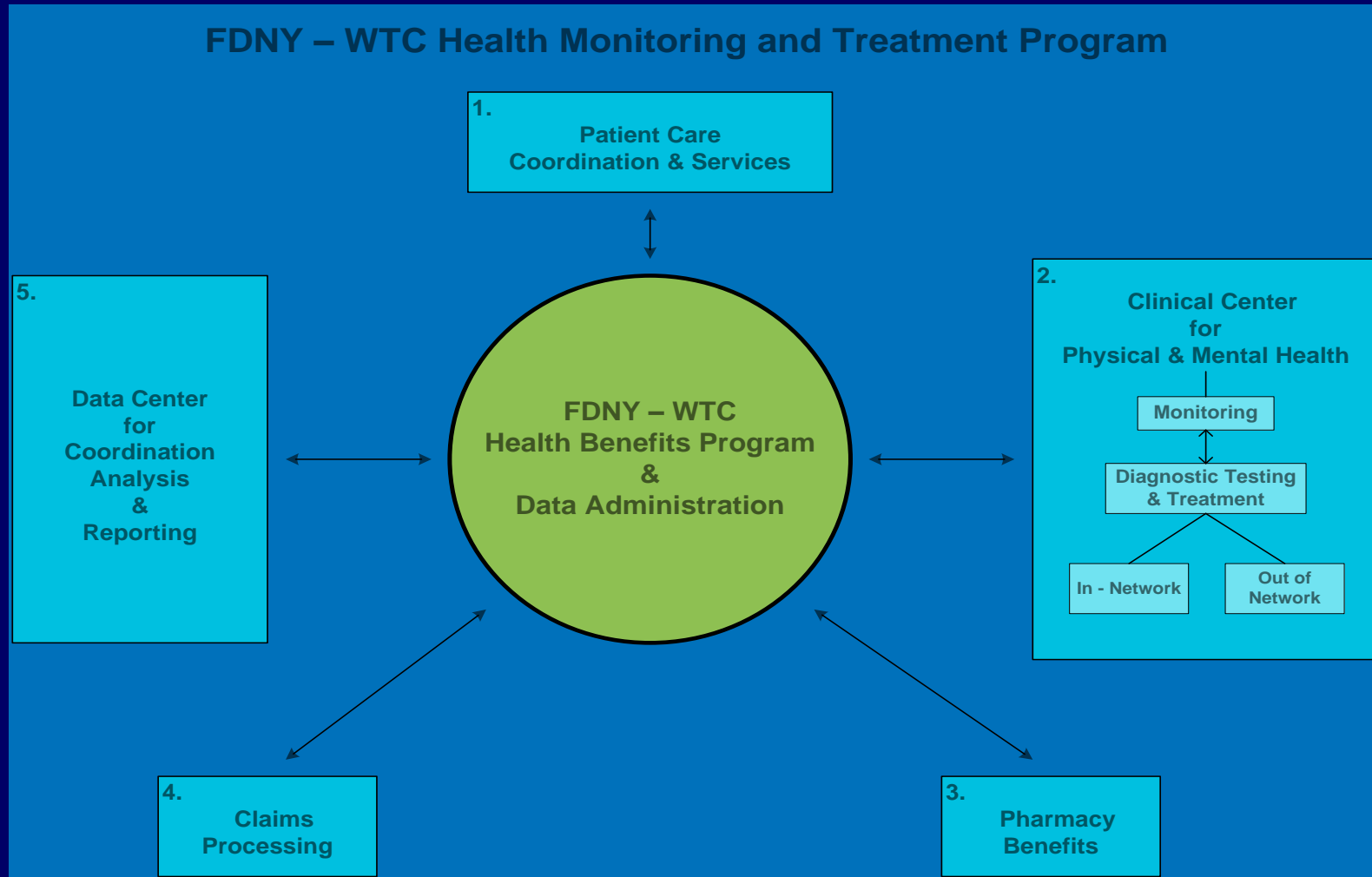
- **~15,700 AT WTC SITE:**
- **Initial Arrival:**
 - **Day 1 - AM of 9/11/01**
 - **14% of workforce**
 - **Day 1 - PM of 9/11/01 & Day 2 - 9/12/02**
 - **60% of workforce**
 - **Day 3-14**
 - **15% of workforce**
 - **After Day 14**
 - **10% of workforce**



FDNY WTC MONITORING EXAM: Patient Flow



FDNY-WTC Monitoring & Treatment Program Delivered Through a Health Benefits Program Model



Clinical <—> Data Integration

Patient Micro Level

- Eligibility determination
- Monitoring
- Treatment
- Pre. vs Post WTC Data
- Diagnostic Testing
- Prescription Meds.
- Medical Records
- Clinician-Patient Relationship

Cohort Macro Level

- Diagnostic Definitions
- Monitoring Protocols
- Treatment Protocols
- Pre. vs Post WTC Data
- Disease Surveillance
- Outcomes
- Programmatic Relationships
 - Patient Groups
 - Medical Community
 - Government

FDNY WTC MEDICAL MONITORING

- **Oct. 2001 to Mar. 2002:**
 - 10,000 Visit 1 Baseline Medicals**
 - **Firefighters, EMS, Officers**
- **Totals through 7/31/11:**
 - **15,375 Baseline Medicals**
 - **(98% compliance)**
 - **Visit 4 Medicals started 2008**
 - **Already 82% of cohort examined**
 - **Visit 5 Medicals**
 - **Already 70% of cohort examined**



COUGH AND BRONCHIAL RESPONSIVENESS IN FIREFIGHTERS AT THE WORLD TRADE CENTER SITE

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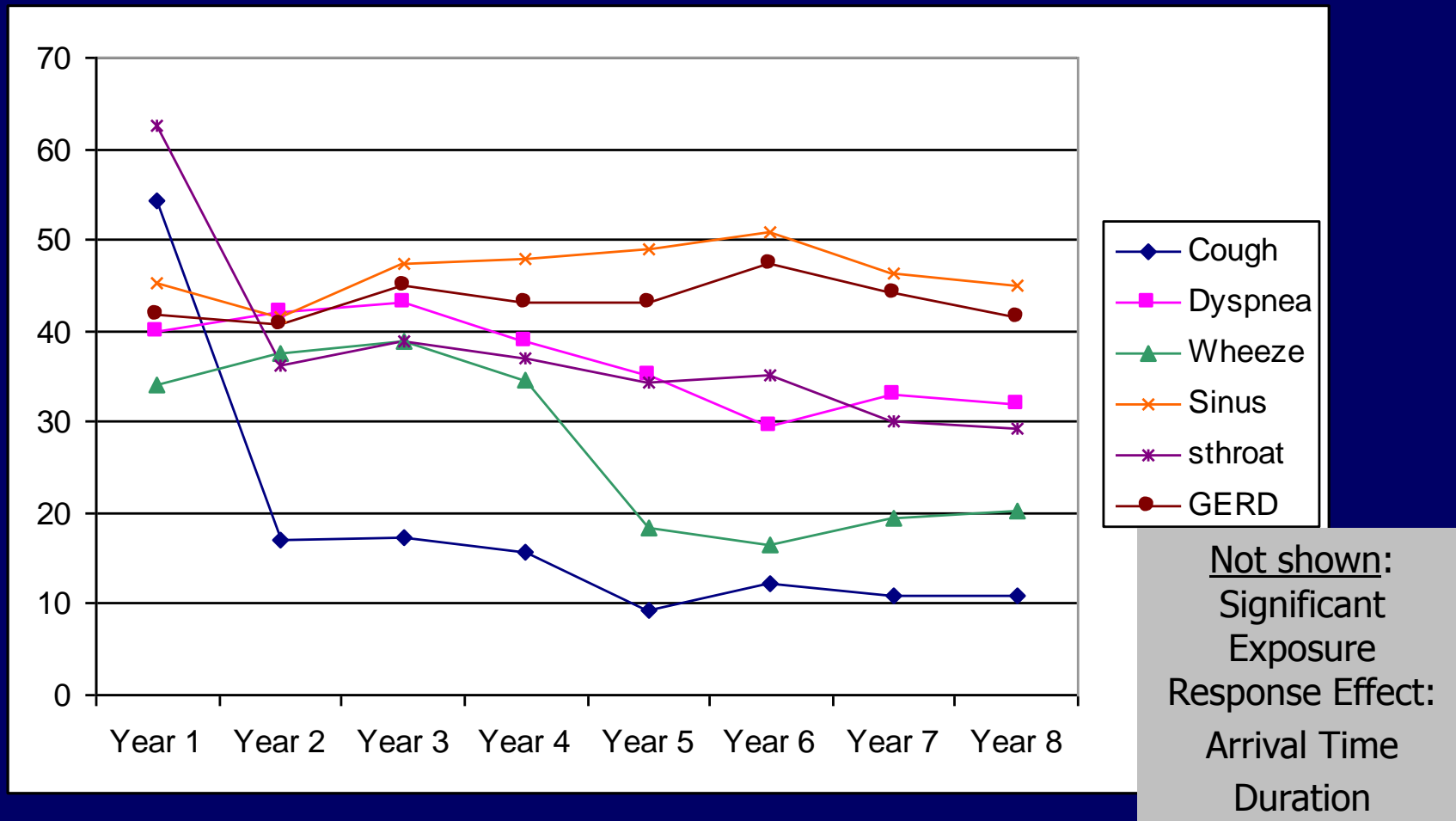
ABSTRACT

Background Workers from the Fire Department of New York City were exposed to a variety of inhaled materials during and after the collapse of the World Trade Center. We evaluated clinical features in a series of 332 firefighters in whom severe cough developed after exposure and the prevalence and severity of bronchial hyperreactivity in firefighters without severe cough classified according to the level of exposure.

Methods "World Trade Center cough" was defined as a persistent cough that developed after exposure to the site and was accompanied by respiratory symp-

THE September 11, 2001, terrorist attack that resulted in the collapse of New York City's World Trade Center led to an intense, short-term exposure to inorganic dust, products of pyrolysis, and other respirable materials. The Fire Department of New York City (FDNY) operated a continuous rescue and recovery effort at the site involving approximately 11,000 firefighters, who were exposed to such respiratory irritants,¹ which have been implicated in the development of airflow obstruction.^{2,3} We identified conditions associated with

Respiratory Symptom Time Trends: Cross-sectional analysis (N=11,315) 2001-2009



1. Webber, Niles, Kelly Prezant et al; Environ Health Perspectives 2009
2. Weakley, Webber, Kelly, Prezant, et al Preventive Medicine 9/2011

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Lung Function in Rescue Workers at the World Trade Center after 7 Years

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Lara Glass, M.P.H., Fairouz Al-Othman, M.D., Michael D. Weiden, M.D., Kerry J. Kelly, M.D.,
and David J. Prezant, M.D.

ABSTRACT

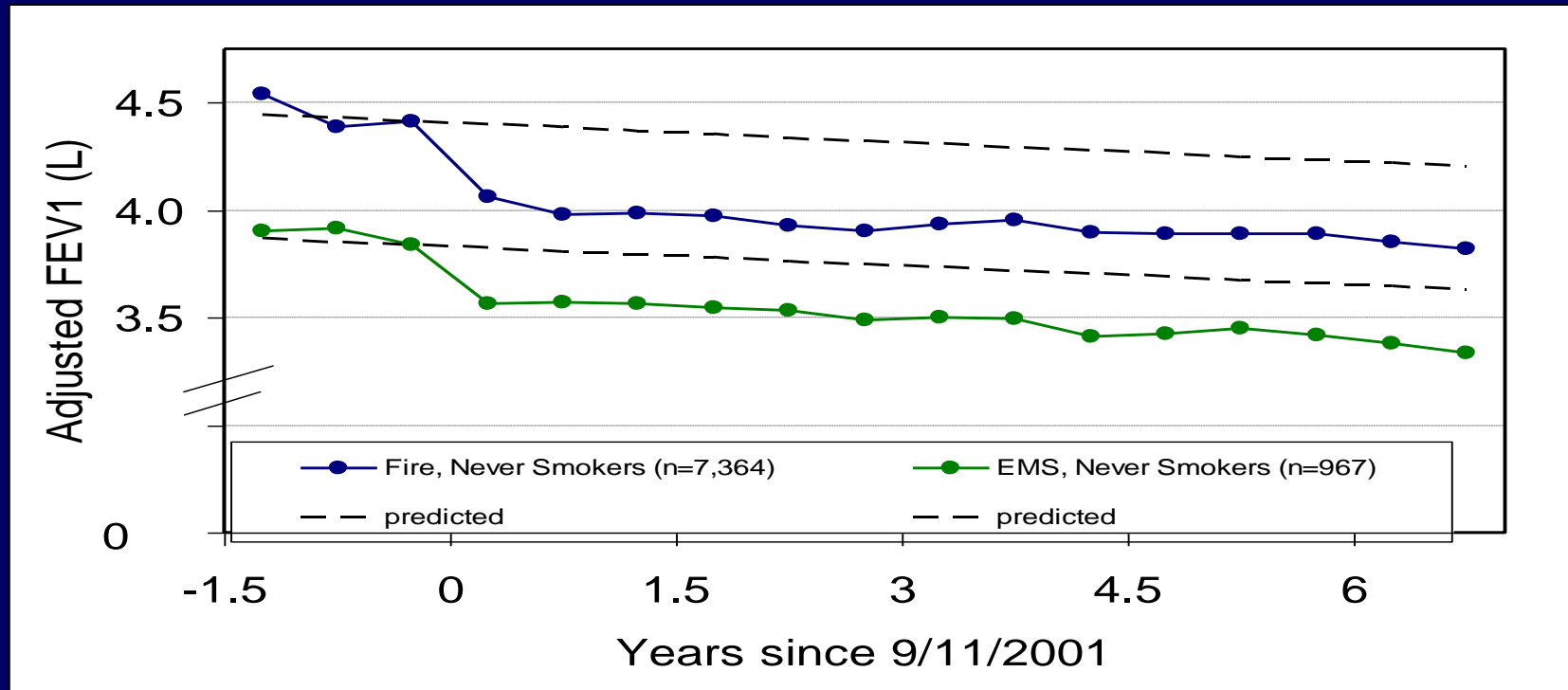
- **OBJECTIVE:** To assess the longer-term lung function trends in FDNY workers exposed to WTC dust
 - On average, did the initial decline in lung function recover, persist, or worsen?

Characteristics of cohort – Post QA

	FIRE	EMS	TOTAL
Number of Persons	10,870	1,911	12,781
Number of Spirometries	48,659	13,083	61,742
Length of Follow-up post-9/11 (median)	6.1 years	6.4 years	6.2 years

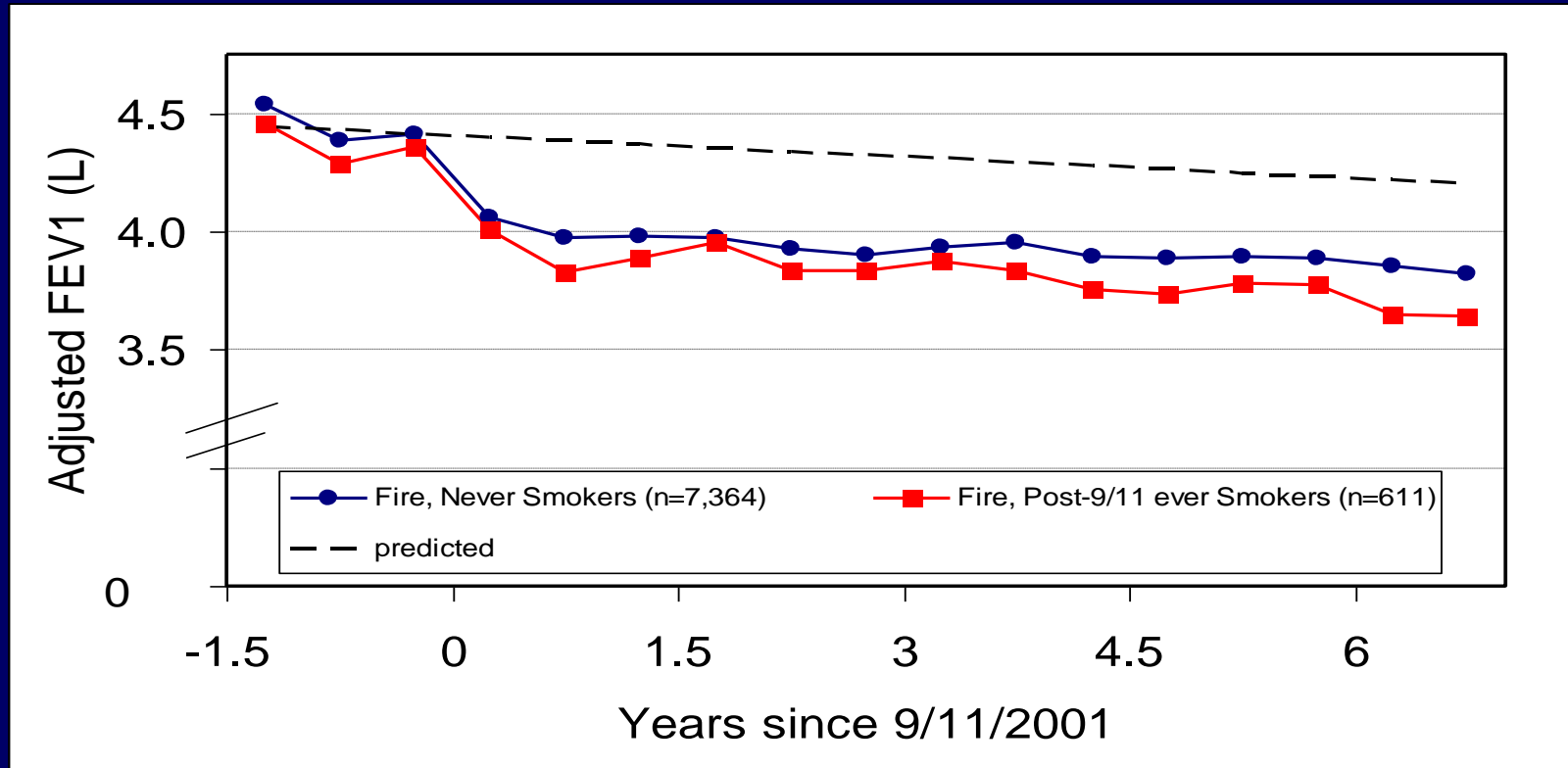
- 2,099 were present during the morning of 9/11

RESULTS: Lung Function Decline Since 9/11: Nonsmoking EMS Exposed to WTC Dust



- Compared to firefighters:
Pre-9/11, lung function was lower, reflecting the higher percentage of women and less rigorous lung function requirements for EMS
- After 9/11, patterns of decline similar but drop in year 1, although substantial, was less than Fire because EMS job-tasks resulted in lesser exposure

RESULTS: Lung Function Decline Since 9/11 Impact of Tobacco Smoke Significant but Small

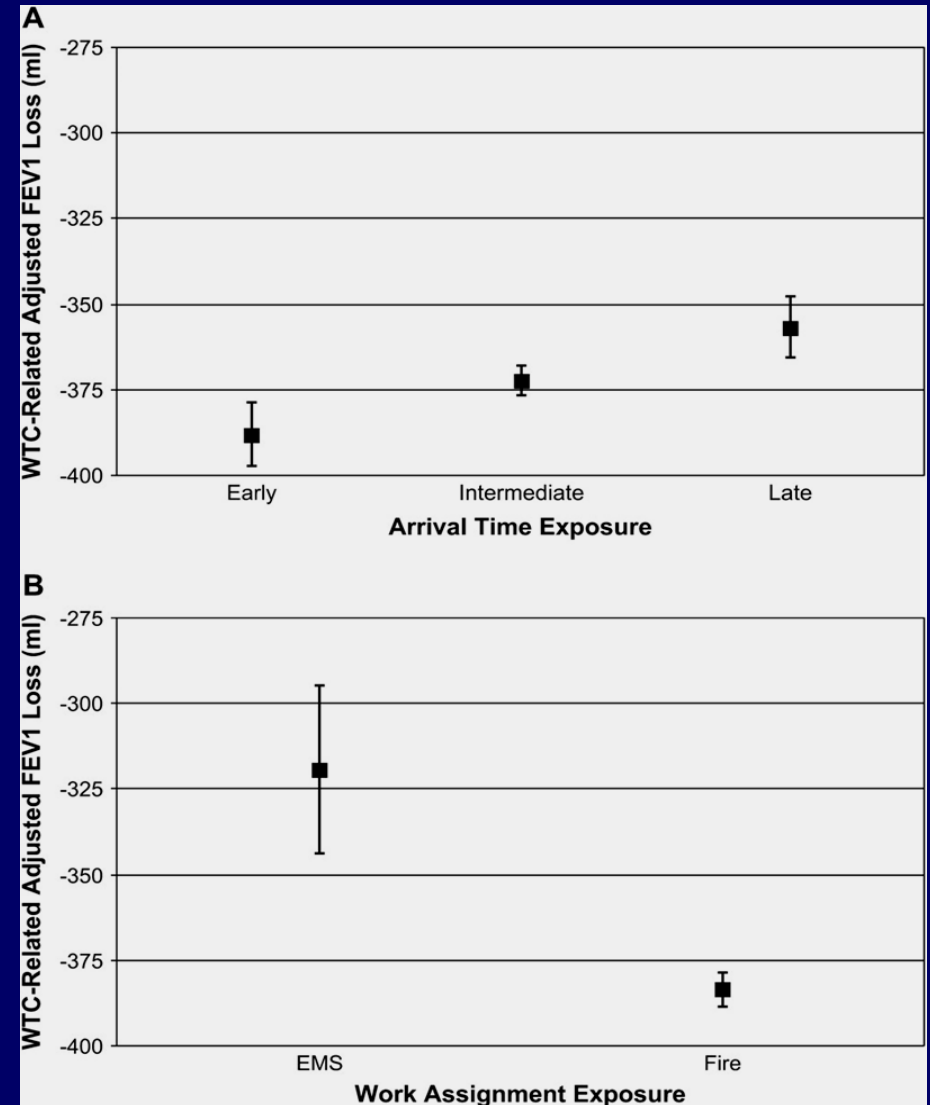


For both Fire & EMS (not shown), cigarette smokers had lower lung function at all time points, but main impact was 9/11 exposure.

Another way to look at decline rates is to determine the percentage of the group developing abnormal lung function.

Short-term effects of WTC exposure: The First Year

- In our first study of lung function, over 12,000 FDNY rescue workers had spirometry with measures of the FEV1 (Forced expiratory volume in first sec.)
- FIRST YEAR POST-9/11:
 - Average decline in FEV1 = 372 ml
 - Approx. 12 times the annual age-related decline pre-9/11
- Greater declines associated with greater exposures:
 - Fire > EMS
 - Yet, EMS still substantial
- Long term outcome not addressed



Banauch et al, AJRCCM 2006; 174: 312.

GROUND ZERO

Firefighters battle 'Trade Center cough'

"WTC COUGH"

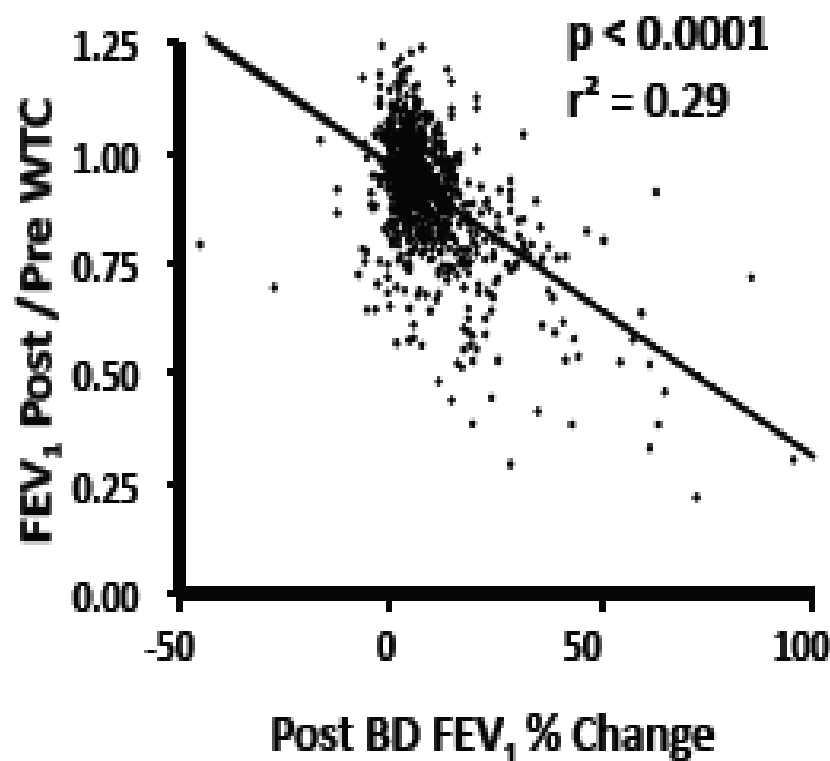
Between 9/11/01 and 3/10/08:

- Syndrome of Asthma, Sinusitis & GERD
- 1,720 Presented for FDNY Pulmonary Evaluation and had all Pulmonary Tests at Single Ctr.
- Obstructive vs. Restrictive Physiology ???

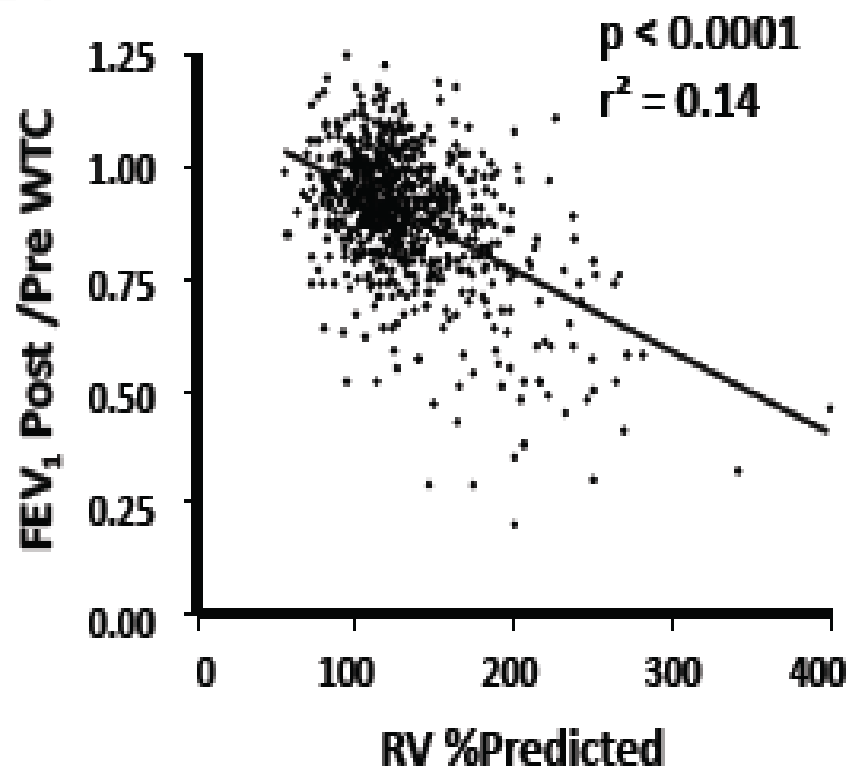
Source: Weiden, Ferrier, Nolan, Rom, Comfort, Gustave, Zeig-Owens, Zeng, Goldring, Berger, Cosenza, Lee, Webber, Kelly, Aldrich & Prezant; CHEST. 2010: 137:1-9

'WTC Cough': Pulmonary Evaluation Cohort (N= 1,720)

A.



B.

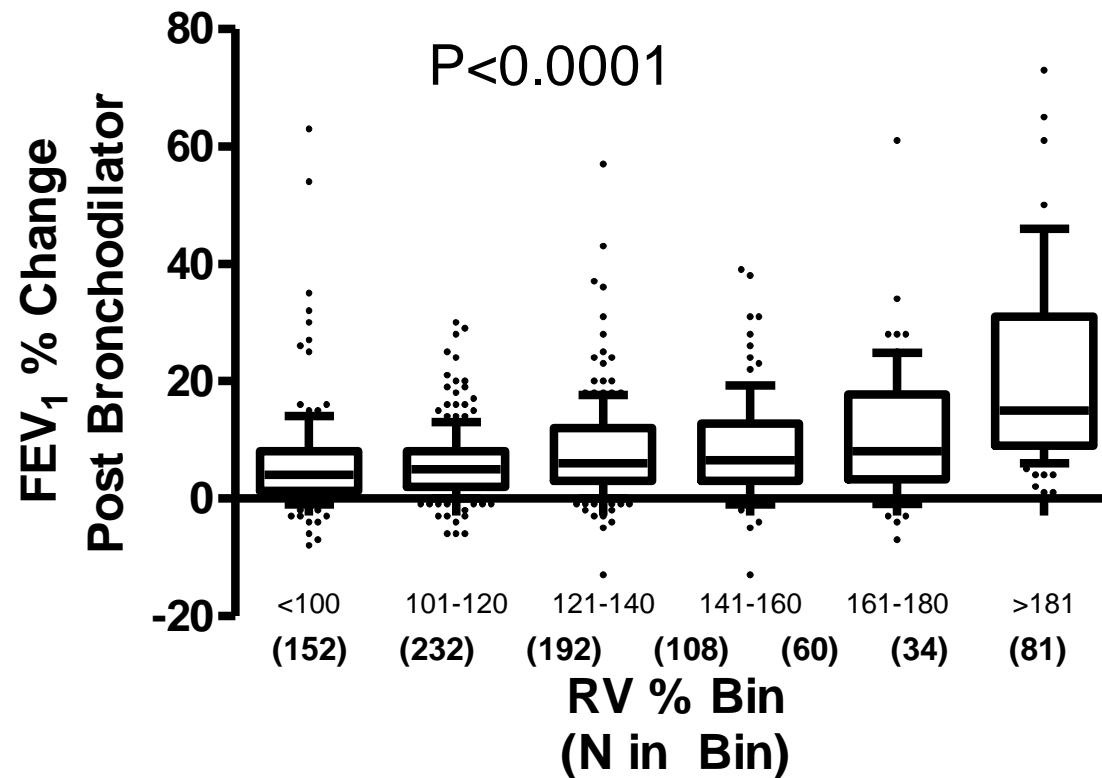


All regressions adjusted for smoking, gender, height, weight, age & race

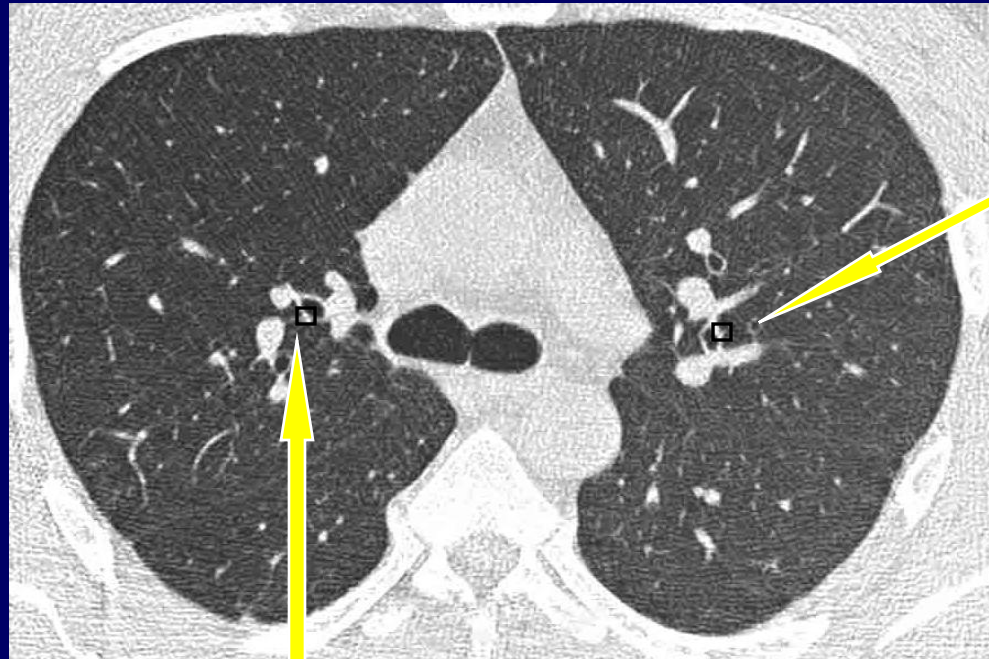
Source: Weiden, et al CHEST. 2010: 137:1-9

'WTC Cough': Pulmonary Evaluation Cohort (N= 1,720)

B.



'WTC Cough': Pulmonary Evaluation Cohort (N= 1,720)



Bronchial Wall Thickening
On Inspiratory Imaging

Bronchial Wall Thickening
On Inspiratory Imaging

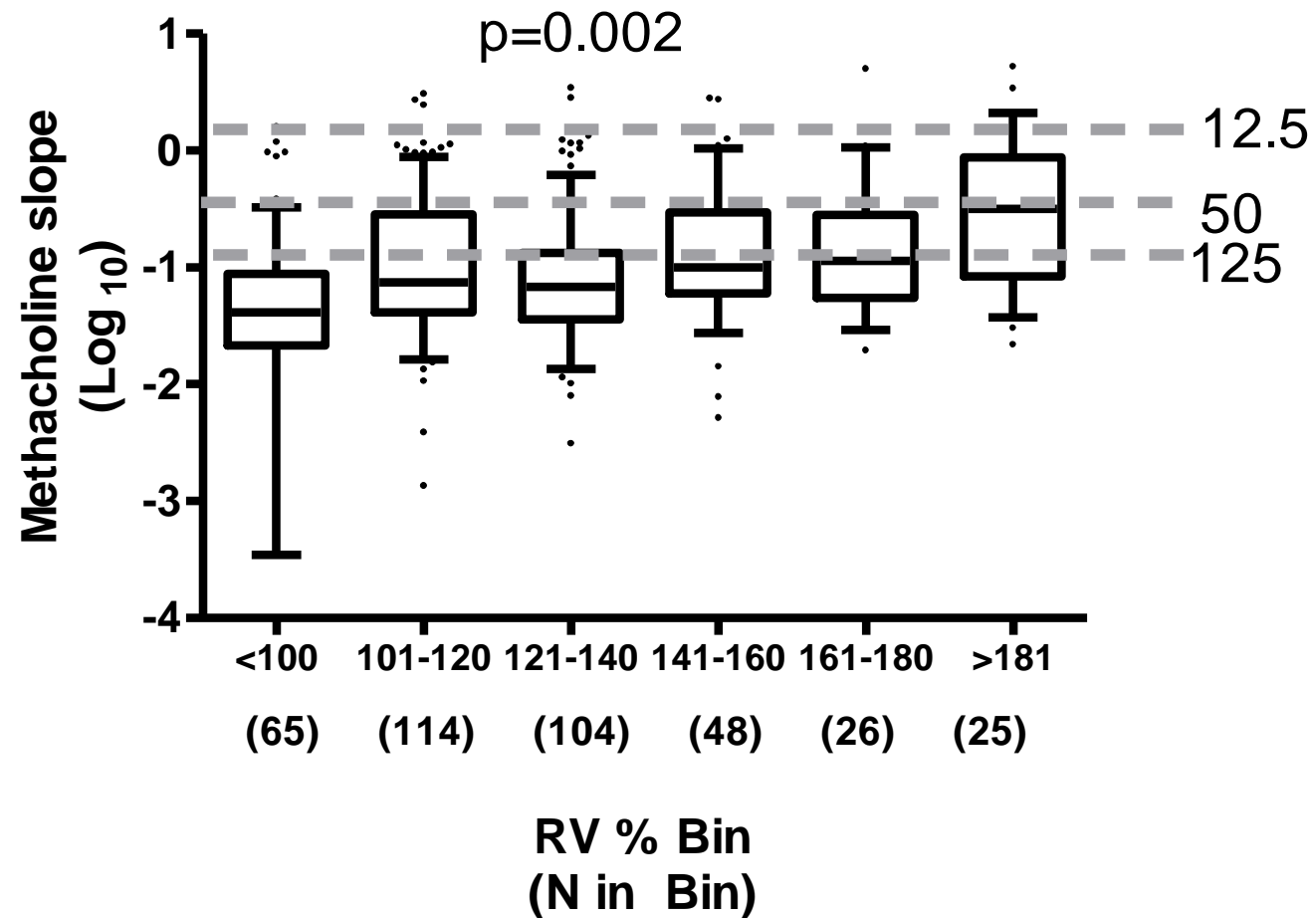


Air Trapping on Expiratory Imaging

Prezant, Banauch, Weiden, Kelly et al; NEJM 2002;347:806-15.

'WTC Cough': Pulmonary Evaluation Cohort (N= 1,720)

C.



'WTC Cough': Pulmonary Evaluation Cohort (N= 1,720)

FDNY Pulmonary Evaluation Cohort:

FEV1/FVC < 0.76 (LLN)

BD Response ($\geq 12\%$),

High RV ($> 120\%$ predicted)

MC Reactivity (slope > 0.13):

Low FEV1/FVC Ratio, BD Response, High RV OR Reactivity:

- 1,015/1,720 (59%)

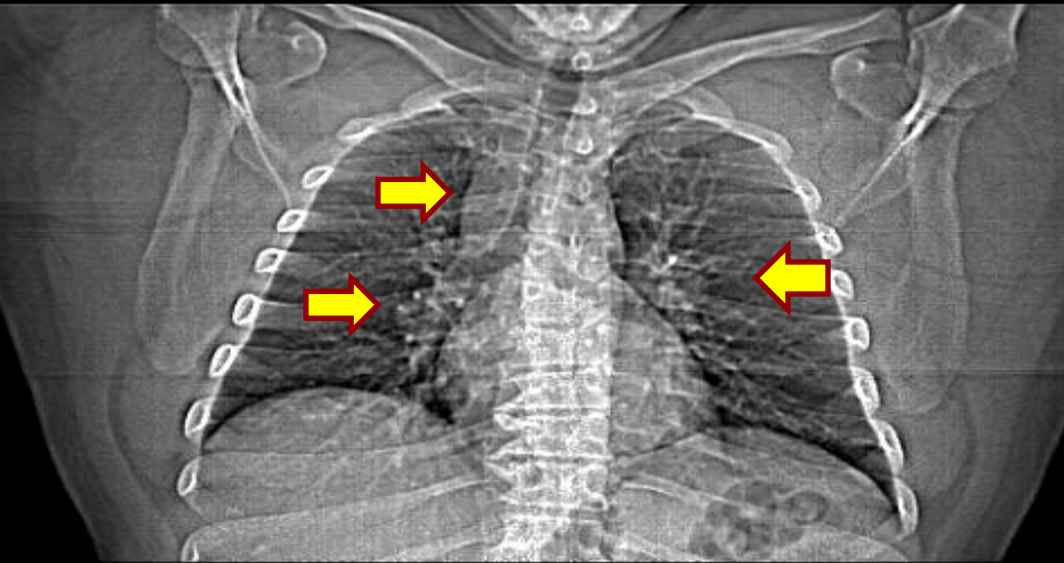
Of the 1,720 only 30 (1.7%) with interstitial disease

- 27 with Post 9/11/01 Sarcoidosis (Volumes & DLCO $< 80\%$ in 1)
- 3 with Interstitial Dx. on CT (Volumes & DLCO $< 80\%$ in 2)

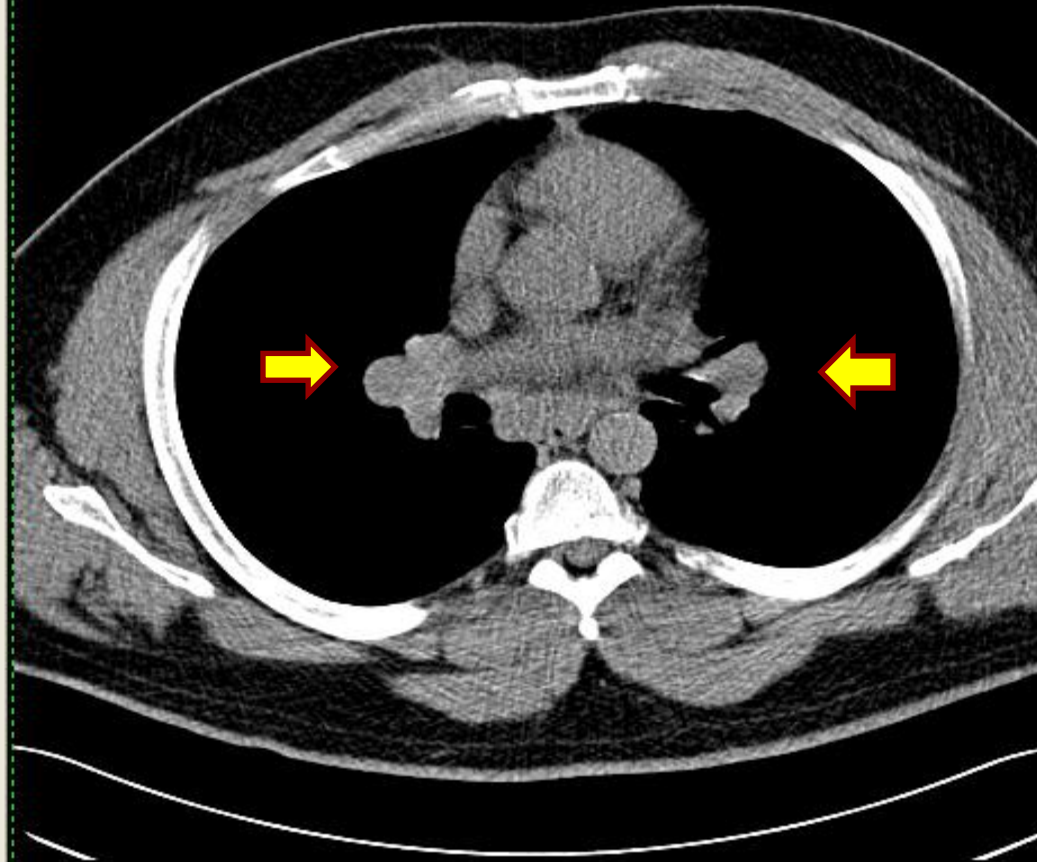
Symptoms without physiologic explanation but not restrictive

- 675/1,720 (39%)

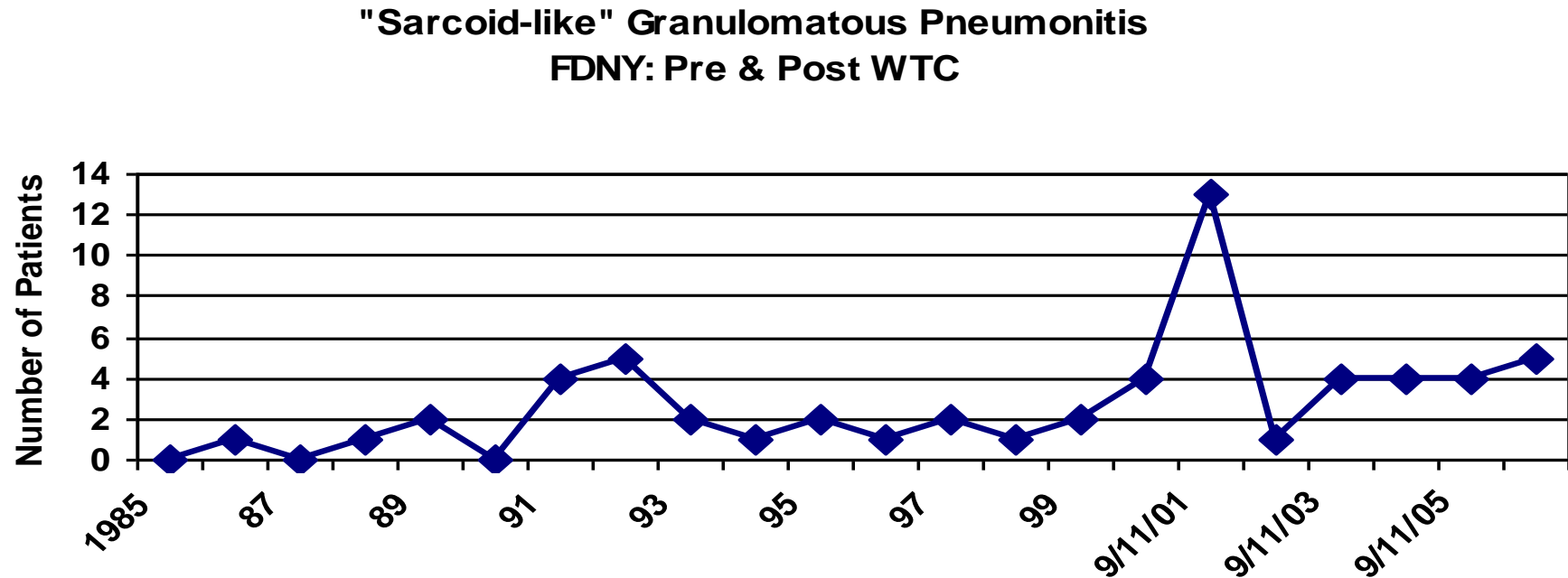
INTERSTITIAL LUNG DISEASE IS RARE



World Trade Center
“Sarcoid-Like”
Granulomatous
Pulmonary Disease



WTC – Related Sarcoid Like Granulomatous Pulmonary Disease in FDNY Rescue Workers



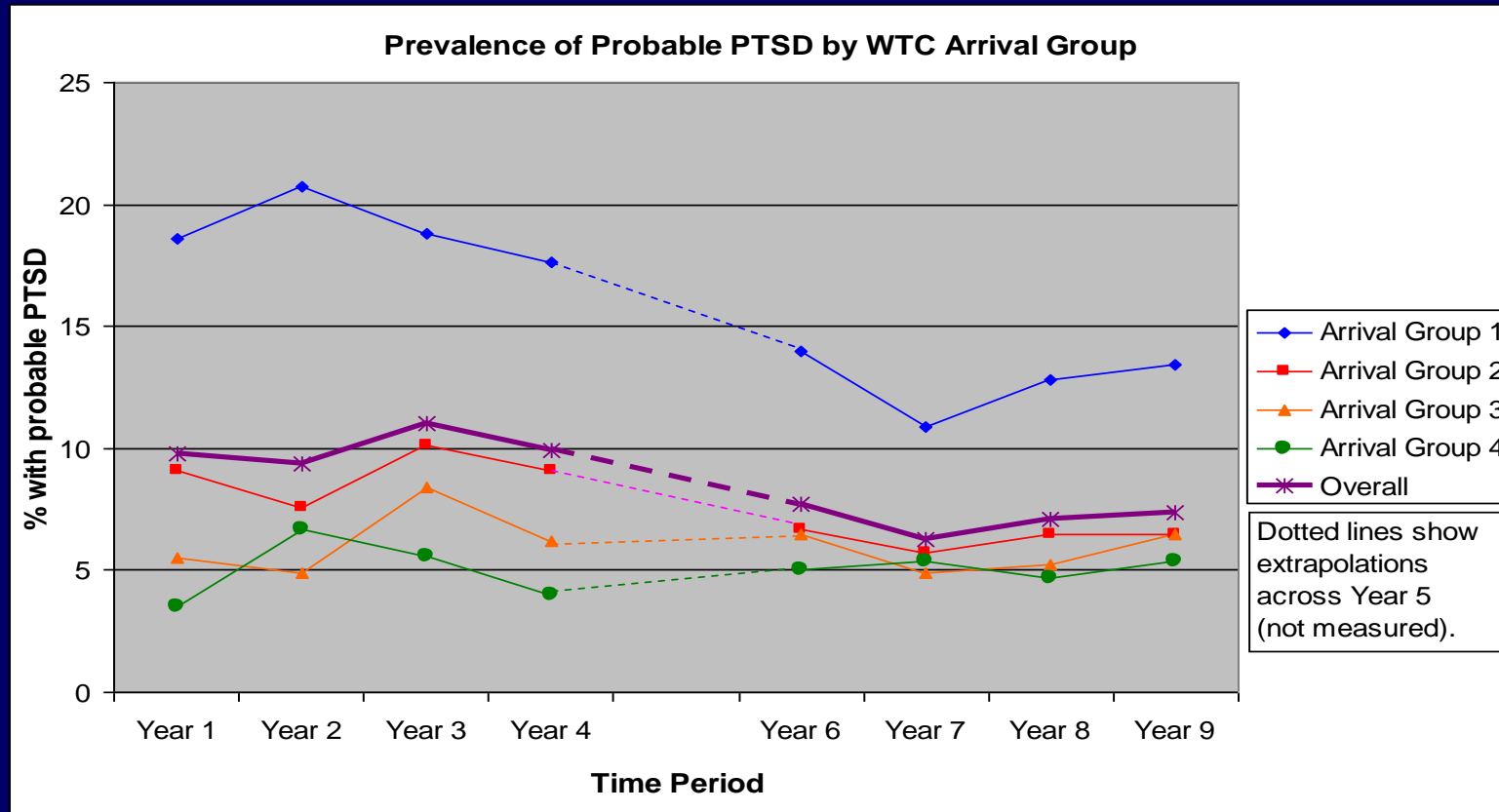
- Pre-WTC = 13 / 100,000 in FDNY rescue workers
- Post-FDNY = 86 / 100,000 in first 12 months; 22 / 100,000 yrs 2-4

Izbicki, Banauch, Weiden, Kelly, Prezant CHEST May 2007

WTC-Related Sarcoid-Like Granulomatous Disease in FDNY Rescue Workers – Clinical Course

- **Pre-WTC:** All with Thoracic Lymph Nodes
- 1 liver, 1 bone, 2 treated (? need)
 - » No Bronchodilator response, No Hyperreactivity
- **Post-WTC:** All with Thoracic Lymph Nodes
- 2 skin (EN), 2 Liver, 3 Bone, 1 Cardiac
 - » Obstructive Airways Disease = 38 to 65%
 - » Oral Corticosteroids = 8 (31 %)
 - » No transplants, no fatalities
 - » Hypersensitivity Pneumonitis unlikely
 - » 6 resolved spontaneously but all cases with lymph nodes ~1/3 with extrathoracic disease

Probable PTSD Time Trends: Cross-sectional analysis 2001-2010 (N=11,006)



Soo, Webber, Kelly Prezant et al; Disaster Med & Preparedness, 2011

WTC FDNY Disability

Between 9/11/01 and 9/10/08:

- WTC Cough Syndrome
- Asthma, COPD, Rhinosinusitis, GERD
- 1,402 either WTC or Lung Bill
- Projected Additional Pension costs = \$826 million - \$104 million (FEMA support)
- \$723 million actual cost

Source: Niles, JK, Webber, MP, Gustave J, Zeig-Owens, R, Lee R, Glass L, Weiden MD, Kelly KJ, & Prezant; Am Ind J Med: 9/2011

Early assessment of cancer outcomes in New York City firefighters after the 9/11 attacks: an observational cohort study

Rachel Zeig-Owens, Mayris P Webber, Charles B Hall, Theresa Schwartz, Nadia Jaber, Jessica Weakley, Thomas E Rohan, Hillel W Cohen, Olga Derman, Thomas K Aldrich, Kerry Kelly, David J Prezant

Summary

Lancet 2011; 378: 898–905

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Background The attacks on the World Trade Center (WTC) on Sept 11, 2001 (9/11) created the potential for occupational exposure to known and suspected carcinogens. We examined cancer incidence and its potential association with exposure in the first 7 years after 9/11 in firefighters with health information before 9/11 and minimal loss to follow-up.

Methods We assessed 9853 men who were employed as firefighters on Jan 1, 1996. On and after 9/11, person-time for 8927 firefighters was classified as WTC-exposed; all person-time before 9/11, and person-time after 9/11 for 926 non-WTC-exposed firefighters, was classified as non-WTC exposed. Cancer cases were confirmed by matches with state tumour registries or through appropriate documentation. We estimated the ratio of incidence rates in WTC-exposed firefighters to non-exposed firefighters, adjusted for age, race and ethnic origin, and secular trends, with the US National Cancer Institute Surveillance Epidemiology and End Results (SEER) reference population. CIs were estimated with overdispersed Poisson models. Additional analyses included corrections for potential surveillance bias and modified cohort inclusion criteria.

Findings Compared with the general male population in the USA with a similar demographic mix, the standardised incidence ratios (SIRs) of the cancer incidence in WTC-exposed firefighters was 1·10 (95% CI 0·98–1·25). When compared with non-exposed firefighters, the SIR of cancer incidence in WTC-exposed firefighters was 1·19 (95% CI 0·96–1·47) corrected for possible surveillance bias and 1·32 (1·07–1·62) without correction for surveillance bias. Secondary analyses showed similar effect sizes.

Interpretation We reported a modest excess of cancer cases in the WTC-exposed cohort. We remain cautious in our interpretation of this finding because the time since 9/11 is short for cancer outcomes, and the reported excess of cancers is not limited to specific organ types. As in any observational study, we cannot rule out the possibility that effects in the exposed group might be due to unidentified confounders. Continued follow-up will be important and should include cancer screening and prevention strategies.

FDNY Study Cohort (n=9,853)

- Study period 1/1/1996-12/30/2008
- Active (not retired) on 1/1/1996
- White, black, or Hispanic males
- Employed by FDNY \geq 18 months
- Known WTC exposure status (exposed or non-exposed)
- Were or would have been < 60 on 9/11

Data Collection

- Linked to state cancer registries in New York, Florida, Pennsylvania, North Carolina and Virginia (Actives are required to live in NYS)
 - Match on various identifying factors such as:
 - Social Security Number (100% of our cohort)
 - First and Last Name
 - Date of Birth
 - Over 90% of those who are currently retired
- Self-reported cases from questionnaires verified

Two Comparison Groups

1. External - US male population using SEER-13

We used SEER rates to calculate expected cancers by age group, gender, race and calendar year because nationally incidence rates have changed over time for certain cancers (ex. increases in thyroid, prostate & melanoma)

2. Internal - Non-WTC exposed FDNY firefighters

Better control for background occupational exposures of firefighting, lifestyle & other confounders. Note, in the future, NIOSH may be able to provide a non-FDNY firefighter comparison group.

Standardized Incidence Ratios (SIRs)

$$\text{SIR} = \frac{\text{Observed Number of Cases}}{\text{Expected Number of Cases (SEER)}}$$

$$\text{SIR ratio} = \frac{\text{Exposed SIR}}{\text{Unexposed SIR}}$$

Correcting Potential Surveillance Bias

- We flagged 25 records for potential surveillance bias:
 - 15 firefighters who had surveillance chest CT scans 6 months or less before a cancer diagnosis (lung, liver, thyroid, non-Hodgkin lymphoma, and kidney).
 - 10 firefighters diagnosed with prostate or hematologic cancers within 6 months of routine FDNY blood tests
- We then performed additional analyses in which we delayed the diagnosis date by two years [SIR 1.21] or delayed the date beyond 2008 [SIR 1.19] and compared the results to those obtained using the actual diagnosis date [SIR 1.32].
- Compared tumor staging by pre vs. post-9/11

Lancet 9/3/2011

	Observed	Expected	SIR (95% CI)
All sites			
Exposed (61 884 person-years)	263	238	1.10 (0.98–1.25)
Non-exposed (60 761 person-years)	135	161	0.84 (0.71–0.99)
SIR ratio*	..	..	1.32 (1.07–1.62)
All sites (corrected)†			
Exposed	242	238	1.02 (0.90–1.15)
Non-exposed	135	161	0.84 (0.71–0.99)
SIR ratio*	..	..	1.21 (0.98–1.49)

Note: After correction for potential surveillance bias, Too few cases to achieve statistical power for any individual cancer analysis.

Specific Cancer Results

Hodgkin's lymphoma

Exposed	0	2	..
Non-exposed	≤5	2	0.82 (0.20–3.27)
SIR ratio*	..	..	..

Non-Hodgkin lymphoma

Exposed	21	13	1.58 (1.03–2.42)
Non-exposed	9	11	0.83 (0.43–1.60)
SIR ratio*	..	..	1.90 (0.87–4.15)

Non-Hodgkin lymphoma (corrected)†

Exposed	20	13	1.50 (0.97–2.33)
Non-exposed	9	11	0.83 (0.43–1.60)
SIR ratio*	..	..	1.81 (0.82–3.97)

Multiple myeloma

Exposed	≤5	3	1.49 (0.56–3.97)
Non-exposed	0	2	..
SIR ratio*	..	..	..

Leukaemia

Exposed	9	6	1.40 (0.73–2.70)
Non-exposed	7	5	1.47 (0.63–3.40)
SIR ratio*	..	..	0.98 (0.33–2.77)

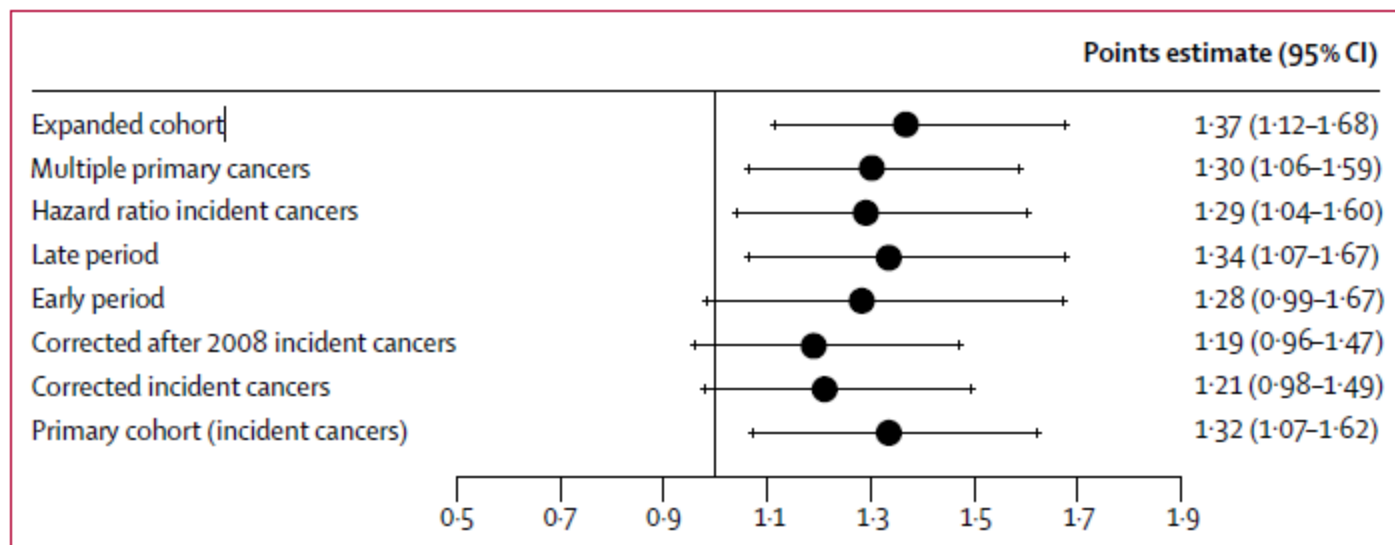


Figure: Primary and secondary analyses displaying point estimates and 95% CIs for all cancer sites combined. Primary cohort (corrected after 2008 incident cancers): standardised incidence ratios (SIRs) ratio of first cancers in World Trade Center (WTC) exposed firefighters versus non-exposed firefighters. Corrected incident cancers: SIR ratio of first cancers in exposed versus non-exposed firefighters, with the diagnosis date delayed by 2 years for 25 cases, which might have been detected by FDNY screening. Corrected after 2008 incident cancers: SIR ratio of first cancers in exposed versus non-exposed firefighters with diagnosis dates delayed to beyond 2008, the study period, for 25 cases that might have been detected by FDNY screening. Early period: SIR ratio of exposed firefighters in the early follow-up period (Sept 11, 2001 [9/11], to Dec 31, 2004) after 9/11, versus non-exposed firefighters. Late period: SIR ratio of exposed firefighters in the late follow-up period (Jan 1, 2005, to Dec 31, 2008) after 9/11 versus non-exposed firefighters. Hazard ratio incident cases: ratio of hazard-ratio rates of first cancers in exposed firefighters versus non-exposed firefighters estimated with the Cox model. Multiple primary cancers: SIR ratio of multiple primary cancers in exposed firefighters versus non-exposed firefighters. Expanded cohort: SIR ratio of first cancers in exposed firefighters versus non-exposed firefighters including those who began employment between Jan 1, 1996, and Sept 10, 2001.

Hypotheses for biologic plausibility

- Presence of known carcinogens at WTC
 - PAH, PCBs, Dioxins, Benzene related to hematologic cancers (shortest latency)
 - Esophageal Cancer related to GERD
 - Testicular and prostate cancer related to combustion byproducts and fine particulates
 - Malignant mesothelioma related to asbestos
- Chronic Inflammation
 - WTC exposure is a known cause of acute & chronic inflammatory illnesses. (asthma, COPD, sinusitis, GERD).
 - Chronic inflammation in turn has been associated with various cancers (non-Hodgkin lymphoma, prostate, thyroid, melanoma)

Conclusions WTC and Cancer

- There may be an early signal that Cancer and WTC exposure are associated
- Future work needs to
 - Study additional populations
 - Study all groups for longer amounts of time (studies in the future)

WTC-Related Disease

Where Are We Now?

RESEARCH:

- Zadroga Act
 - NIOSH Federal WTC Research Program
- Increased funding:
 - Beyond case studies & cross-sectional analyses
 - Stress collaboration and peer-review
 - Basic science, mechanisms, can now be explored
- Problems that require immediate solutions
 - Can disease surveillance for NEW illnesses be done?
 - Can time-critical research be done?
 - Can peer-review be done effectively?

WTC-Related Disease

Where Are We Now?

RESEARCH:

- Problems with immediate solutions
 - Can disease surveillance for NEW illnesses be done?
 - Can time-critical research be done?
 - Data centers linked to clinical centers are the first to know and can perform clinical and epidemiologic research in the most rapid and efficient manner
 - Project Program Grant Awards should be used to continue and expand upon this proven research process
 - Career Investigator Awards should be used to provide those who have demonstrated their ability to succeed.
 - Individual Awards (RO1) should be used for hypothesis driven mechanistic research which is not as time sensitive and which the data centers are not equipped to do.

WTC-Related Disease

Where Are We Now?

RESEARCH:

- Awards based on peer-review
- Should continue but across a level playing field.
 - Peer grading
 - Study section meeting after peer grading
 - Scores normalized and prioritized

Lessons Learned:

- Pre-Disaster Health Baselines including pulmonary function and mental health screening
- Protect workers by training and education BEFORE disaster
- Strict enforcement of worker protection laws at the disaster site especially after initial rescue effort
- Register all workers (electronic id cards) to know # exposed, locations of exposure, times and durations
- Restrict worker hours/exposure to hazardous environments
- Integrated Programs work best – Monitoring, Treatment and Research – each feeding and growing off each other

THANK YOU

